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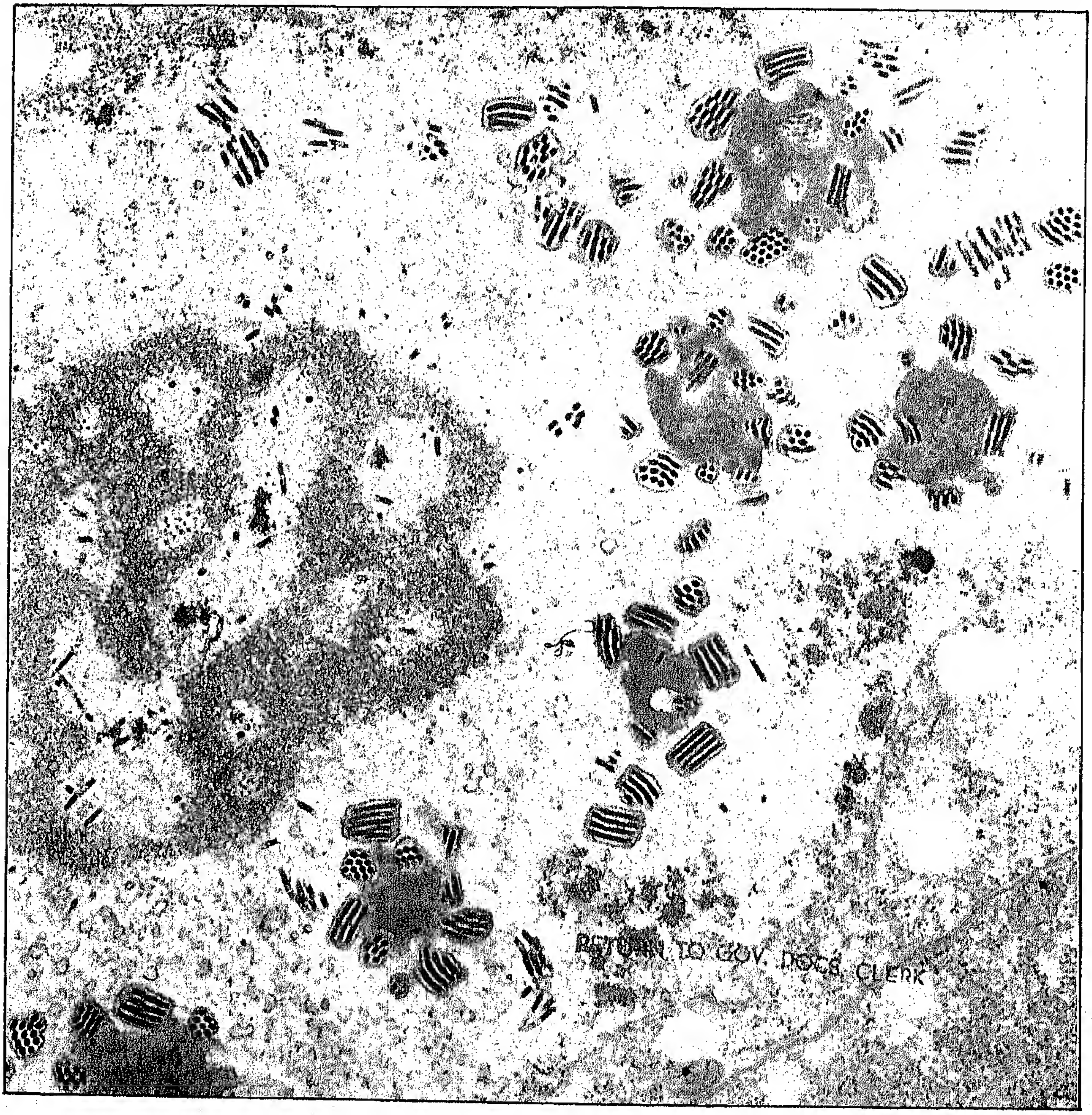

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

Forestry Research West

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Cover

This is a section of a cell of a dying Douglas-fir tussock moth larva, enlarged 29,000 times. Why is the larva dying? It has been exposed to a new insecticide, developed by researchers at the Pacific Northwest Station, that is a promising, new, natural, nonchemical means of controlling Douglas-fir tussock moths. Details begin on page 1.

To Order Publications

Single copies of publications referred to in this magazine are available without charge from the issuing station unless another source is indicated. See page 25 for ordering cards.

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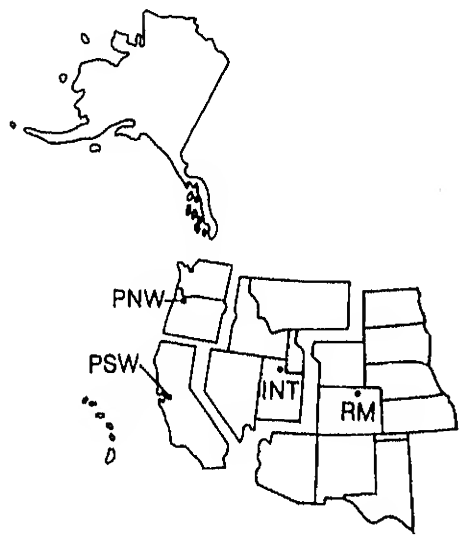
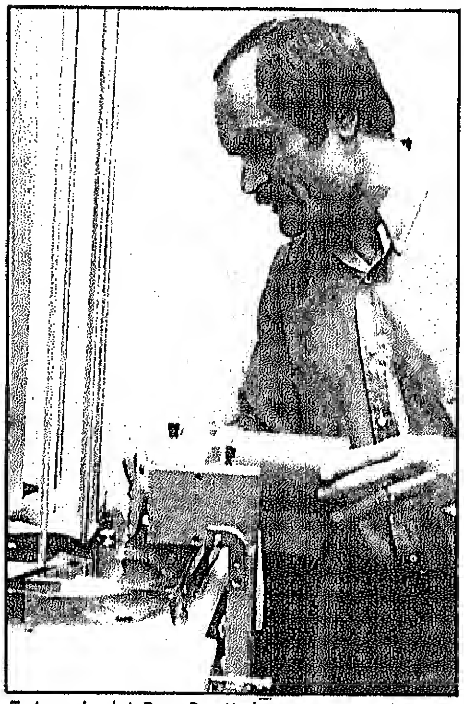
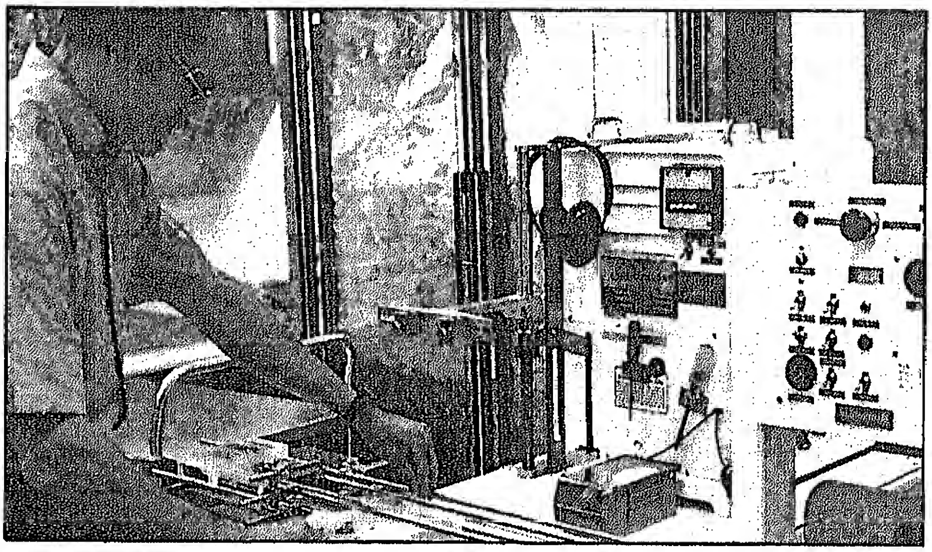


Corvallis laboratory mass produces new insecticide

by Dorothy Bergstrom
Pacific Northwest Station





Entomologist Don Scott demonstrates the use of equipment that was adapted to automatically dispense (1) measured amounts of tussock moth eggs into petri dishes (left photo), and (2) diet to rearing dishes.

When the next outbreak of the Douglas-fir tussock moth is detected in forests of the western United States, forest managers should be better prepared to cope with it, thanks to development of a new insecticide—TM BioControl-1. The lethal ingredient in the insecticide is the nuclear polyhedrosis virus (*Baculovirus* subgroup A), which causes a fatal disease that contributes to the natural collapse of tussock moth outbreaks.

TM BioControl-1 is a natural, non-chemical means of insect control that is both effective and safe. It was developed during 15 years of research at the Forest Service's Forestry Sciences Laboratory (FSL), Pacific Northwest Station, in Corvallis, Oregon, and is now being mass produced in Corvallis for use in the next outbreak. By fall 1985, enough virus should be available to treat 200,000 acres of forest.

The Pacific Northwest Region of the Forest Service geared up to produce the virus in 1980 after a private company defaulted on the job because of costs and difficulties associated with raising large numbers of insects. In addition to producing the virus, the goal is to develop suitable production techniques so the job can be done by private enterprise in the future.

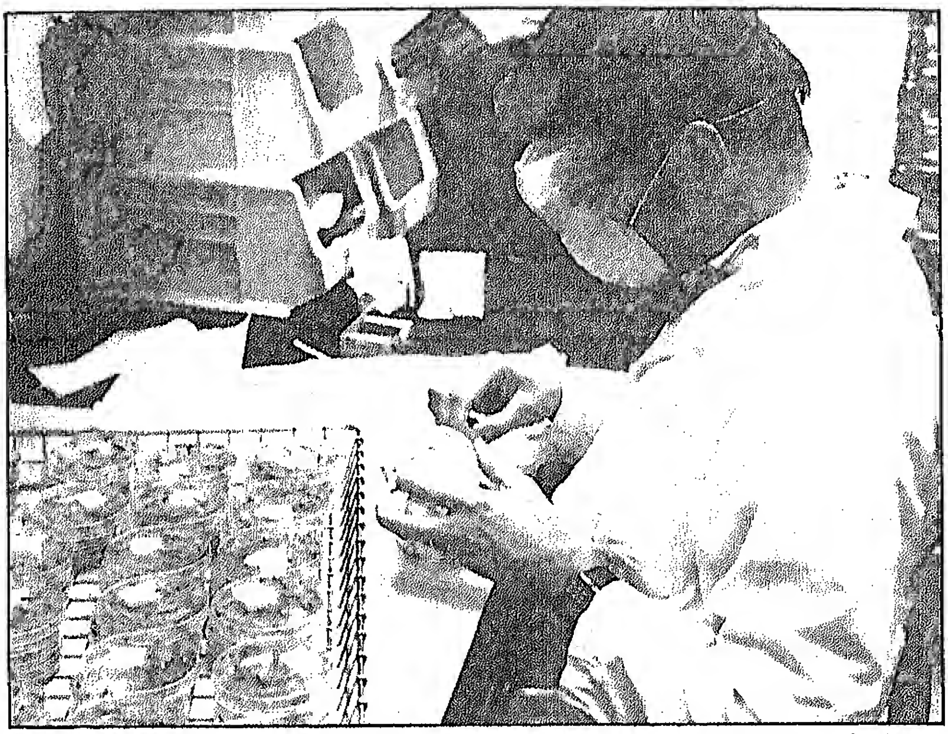
The virus production work is directed by Don Scott of the Region's Forest Pest Management staff. Scott is an entomologist who gained his experience in microbial control while working for the Pacific Northwest Station in the mid-1970's. Microbiologist Mauro E. Martignoni of the Station's Forestry Sciences Laboratory in Corvallis, is technical adviser for the project. He is responsible for setting standards and monitoring product quality. Martignoni has directed most of the Station's basic laboratory work on the virus for the past 20 years.

Scott and his staff of eleven scientists and technicians are responsible for rearing the insects and propagating the virus. The work is done in four different laboratories, by separate staffs who follow rigid procedures to safeguard the insects from contamination by other disease organisms. Three laboratories are used for insect rearing and diet production. Those are located at the FSL in Corvallis. The fourth laboratory is devoted to virus propagation and is at the Corvallis airport.

Because the virus is produced in the bodies of infected tussock moth larvae, Scott's first job was to raise large numbers of tussock moths. Larvae collected from the forest could not be used because nothing was known about their genetic background and health. Fortunately, a starting colony was available from a disease-free strain developed by Martignoni and biological laboratory technician Paul J. Iwai at the FSL in Corvallis. Scott and his staff have modified the rearing methods for purposes of mass production.

The approach

"It took us about a year to gear up to large-scale insect rearing," Scott said. "We modified some of the food-preparation equipment available commercially to mix the diet and automatically dispense measured amounts. We also had to be able to take some of the equipment apart for cleaning and autoclaving and take other measures to reduce possibilities for contaminating the insects."



Technician Dave Edwards removes food partly eaten by rearing larvae and adds a new supply of food. This is done every 7 to 10 days.

One laboratory at the FSL is a "kitchen" where the artificial diet is prepared several times a week. This tofu-like product contains agar, sugar, wheat germ, wheat germ oil, milk protein, vitamins, and water. Antibiotics are also added to prevent deterioration caused by common bacteria and fungi.

Another laboratory provides quarters for reproduction. There, adult tussock moths emerge from their pupae, and males—which can fly—find the flightless females. After mating, the females lay clusters of eggs on the pupal cases from which they emerged. Egg masses are collected then refrigerated for 4 months to simulate natural diapause.

After 4 months, the eggs are washed, rinsed with sterile, distilled water, and put in petri dishes for rearing, which takes place in the third laboratory. In about 14 days, the eggs hatch into 1/8-inch larvae that eat, grow, and molt several times. When they are about 4 weeks old, approximately 90 percent of the larvae are consigned to virus production and 10 percent to the breeding colony that perpetuates the laboratory strain.

Larvae designated for virus production are taken to a separate building at the Corvallis airport, 6 miles from the virus-free laboratories in Corvallis. Under the supervision of microbiologist Anita Hutchins, the 4-week-old larvae are fed a diet inoculated with the virus, which then multiplies in the larvae. The larvae die quickly—within 14 days—and are frozen for storage.

According to Scott, the amount of virus in a single frozen larvae is about 25,000 times the amount of virus the larva was fed. As insect rearing procedures have been improved for mass production, yields of virus have increased to about 2,000 acre doses per month. "It takes about 150 infected larvae to produce enough virus to treat one acre of forest," Scott says. "As we have become more efficient, the cost has been reduced below $10.00 per acre, which compares favorably with other insecticides in current use."

Strict sanitation is observed in all the laboratories, and workers in the virus production lab do not visit the other facilities. "We are constantly alert to prevent contamination of insect colonies," Scott says. "Infection with any organism but the virus could compromise our entire operation."

The lab staff is also protected from the skin irritation caused by tiny hairs on the larvae that often affects people who work around tussock moths. They wear protective clothing and masks. Exhaust hoods are used in some operations to draw off irritating particles.

Insects to insecticide

When enough frozen larvae have been accumulated to make up 200,000 acre doses of insecticide, a commercial firm will be given a contract to prepare the insecticide. The larvae will be freeze-dried to remove excess water, and the remaining dried material will be milled into a fine powder so it can pass through filters in aerial spray equipment. When the spray is mixed, adjuvants, such as molasses, will be added to keep the spray from evaporating before it reaches the forest canopy and help it adhere to the foliage. An ultraviolet ray absorber will be added to screen out the radiation that kills the virus.

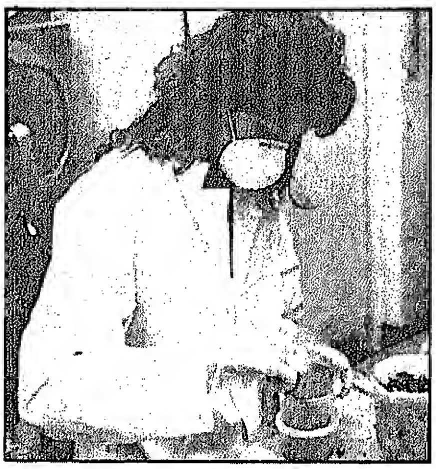
The story of the virus, from its discovery by scientists in 1947 to its role as the primary ingredient in an effective, environmentally safe insecticide, is an example of how basic research can pay off in practical solutions to forest management problems.

Current production of the viral insecticide is possible because of intensive research on the virus that began at the Pacific Northwest Station in 1965, under the direction of entomologist C. G. Thompson. The pace of research accelerated in 1974, when the Douglas-fir Tussock Moth Research and Development Program was authorized by Congress, following the most recent outbreak of the insect. From 1971 to 1974, defoliation on thousands of acres of forest in northeast Oregon, southeast Washington, and Idaho, was so serious that in 1973 the Forest Service requested permission from the Environmental Protection Agency (EPA) to use DDT to spray more than 400,000 acres. In granting permission for an exception to the ban on DDT for forest use, Russell Train, then director of EPA, emphasized that foresters would have to come up with a substitute: that DDT would not be used again for large-scale spraying of forests.

Scientists at the Pacific Northwest Station met the challenge, and on August 11, 1976, the viral insecticide TM BioControl-1 was registered by EPA for use in controlling future tussock moth outbreaks.

The virus kills by entering the gut of the Douglas-fir tussock moth larva with food. Digestive juices then release infectious virus particles (virions) that invade susceptible tissues. As the virus particles multiply and spread the infection, the body contents liquify and death results. The infection is spread when the skin of the dead larva ruptures and virus contaminates adjacent foliage.

Martignoni was responsible for most of the laboratory research leading up to registration of the insecticide. He says the beauty of using the natural virus as an insecticide is that tussock moths in the forest become infected and spread the virus, hastening the end of the outbreak. The spread of the virus is not only horizontal—to the current generation of insects—but also vertical, because the next generation will be infected through virus deposited on egg masses by wind and rain. "We are increasing the amount of virus available by producing it in the lab," Martignoni explains. "Then we intervene in the distribution system by spraying it at appropriate times and places to speed up a natural sequence of events."



Biological aid Stacey Linschoten separates virus-killed tussock moth larvae from frass and diet remnants in preparation for freezing.

Potency tests

A crucial step in Martignoni's research was finding a way to determine the potency of virus. He established measures of potency, expressed as activity units per gram of product, and as polyhedron-to-bioactivity conversion factor, that are used to compute the amount of virus that will be delivered to the forest canopy in various spray formulations. In the current virus production operation, the potency of each batch of larval cadavers is determined and recorded.

The potency of the virus depends on its purity, Martignoni found. Unless the larvae are healthy, they will not produce high virus yields. This discovery was the basis for the strict sanitation procedures of the current operation that protect the breeding colony from infection with other disease agents.

Martignoni's research currently includes improving production of the Douglas-fir tussock moth virus for insecticide use. He has identified other insects in which the virus multiplies when they are deliberately infected in the laboratory, although it does not occur in them naturally. Some of these possible hosts produce more virus in a shorter time and are easier to raise in large numbers. The prospects are good that in a few years research will develop a viral insecticide that is less expensive and easier to produce than TM BioControl-1.

During the next outbreak, the Pacific Northwest Region of the Forest Service will probably use TM BioControl-1 to introduce the viral disease in selected areas at times most likely to end the outbreak sooner. Thanks to research, the next outbreak will be detected earlier by use of pheromone trapping. It will also be evaluated more extensively before decisions are made to control it. Better ways of estimating levels of defoliation are also available.

A description of virus production procedures is included in "The Douglas-fir Tussock Moth: A Synthesis," the primary publication of the Douglas Fir Tussock Moth Program, published in 1978. It is available from the Superintendent of Documents, stock no. 001-000-03924-5. Martignoni discusses current research on insect virus production and uses in a chapter written for the American Chemical Society Symposium Series No. 238, titled *Baculovirus: An attractive biological alternative.* Reprints (distribution no. 83-188) are available from the Pacific Northwest Station.

Biological aid Clara Mills prepares to freeze 6 kilograms (200 acre doses) of dead tussock moth larvae. Later the larvae will be processed into dry powder, the final step in producing the biological insecticide TM BioControl-1.

A long look at P-J woodlands

by Len Miracle
Intermountain Region

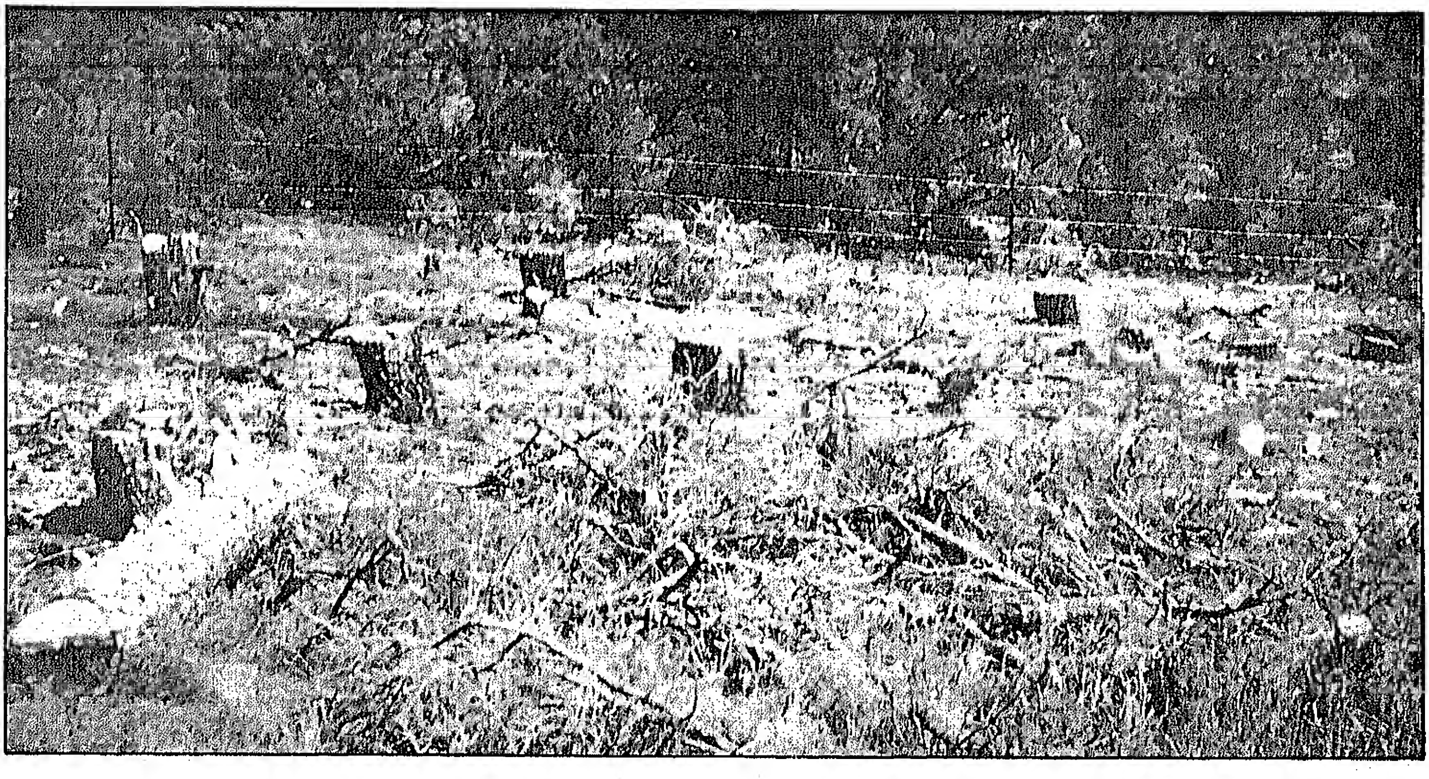
Pinyon-juniper woodlands are abundant in the Great Basin, covering foothills and mountains in Nevada, western Utah, and southern Idaho, eastern California, and northern Arizona. But scientists are concerned about the future of the woodland because of its recent expansion and because of the somewhat wasteful and inefficient control methods now used.

The ultimate welfare of this woodland empire may hinge on the findings of such scientists as Dr. Richard Everett of the Intermountain Station's research unit in Reno, Nevada. Everett is project leader for research dealing with the ecology and management of pinyon-juniper woodlands in the Great Basin.

This plant resource occupies some 17 million acres that have been used and abused for more than 100 years. Most of it is public lands that were overgrazed by transient bands of sheep, cattle, and horses before the start of this century. Later these lands gave more than they could to help meet the nation's need for red meat in both world wars. Mining and ranching developments in the late 1800's leveled thousands of acres of "P-J" woodland for posts, poles, railroad ties, firewood, and wood for charcoal that fueled smelters at mining developments.

Starting with the discovery of the silver-rich Comstock Lode in Nevada in 1858, the Great Basin mining boom immediately enlisted hundreds of American workers who did nothing but cut pinyon and juniper for firewood and charcoal. Chinese laborers swarmed over the same area later, salvaging stumps and roots from the cut-over hills. By 1870, an estimated 4,000 to 5,000 acres of P-J woodlands were cleared each year to fuel the mining operations at a single site—Eureka in central Nevada.

Broadcasting slash after fuelwood harvest returns nutrients to the soil and prevents livestock grazing damage to fragile understory plants. Slash is the cheapest fence we can buy to prevent grazing damage and arrest erosion.



Woodcutters finally ranged as far as 25 or 30 miles from Great Basin mining towns to find trees. Ranchers and commercial dealers in fence posts and railroad ties traveled the hills with wagons leaving stumps and dim trails behind them. Livestock, wild horses, and wildlife grazed unrestricted where forage could be found. Fires burned unchecked where there was enough dry ground cover to carry the flames. Seas of cheat grass invaded the Great Basin as native grasses were depleted.

Those were the bad days. They faded away in the 1900's. There were several reasons. Mines played out. Railroads and improved highways brought in fossil fuels and commercial fencing and building materials to replace the Great Basin trees that had served those purposes. New fences and laws increasingly regulated livestock, wild horses, and wildlife. Range and forest fires were more controlled.

Lands altered

But the Great Basin woodlands—including stands of trees that were well established when the Pilgrims landed at Plymouth Rock—were substantially altered in those pioneer days. Cut-over lands sprouted new trees that grew without the natural control of the range fires. Heavy grazing had reduced the grass and shrubs in most places so that lightning-sparked fires, common throughout the region, lacked the surface fuel to carry from tree to tree. Fewer fires were set by ranchers clearing the land. Organized fire fighters controlled starts in most places where fuels were abundant.

Lacking the mechanical check of woodcutters and the natural toll taken by wildfire, pinyon and juniper seedlings invaded large areas that had previously been dominated by tall sage mixed with other shrubs and an understory of native grasses. Eventually those trees formed a net of roots and canopy of branches that crowded out grass and shrubs. The exclusion of undergrowth was almost complete in many instances.

Then came the years of tunnel vision aimed at removing trees to improve grazing for livestock. Woodlands were also cleared to improve wildlife habitat. Treatments were not greatly successful and the wood resource was often wasted in the process.

Because the ideal state of a P-J woodland depends on the use the viewer has in mind, ranchers favored a scene with lots of grass and few trees. This can be accomplished by spraying or treating areas with chemical pellets, but "chaining" is the method that does a fast and dramatic job. Chaining is a system that uses a length of naval-size anchor chain towed between two crawler tractors to yank out trees by the roots. This method is effective in mature stands with few springy saplings that will bend with the chain and snap upright when it passes. Chained and seeded, a P-J woodland becomes an improved pasture. A sight to delight the ranchers.

Hunters and wildlife managers prefer a slightly altered scene. One with patches of trees interspersed with clearings that support a vigorous growth of shrubs, forbs, and grasses. This can be accomplished—if all goes well—with a little chaining, controlled burning, and perhaps seeding of plants palatable to wildlife species. In many cases, deer numbers remained unchanged after such P-J treatments. What seems likely to work may not. What seems simple can be most complex.

And a new breed of woodcutters has covetous eyes on the P-J woodlands. They're responding to prices of $100 and up for a cord of firewood delivered to such population centers as Reno, Nevada. Their ideal management plan would produce a solid sea of trees. Work of such scientists as Dr. Jerry Budy at the University of Nevada-Reno, could result in regeneration of trees in cut-over areas. Budy has determined that nutrient requirements of pinyon are high and seeks to increase seedling survival and growth for future high yield.

Commercial interest

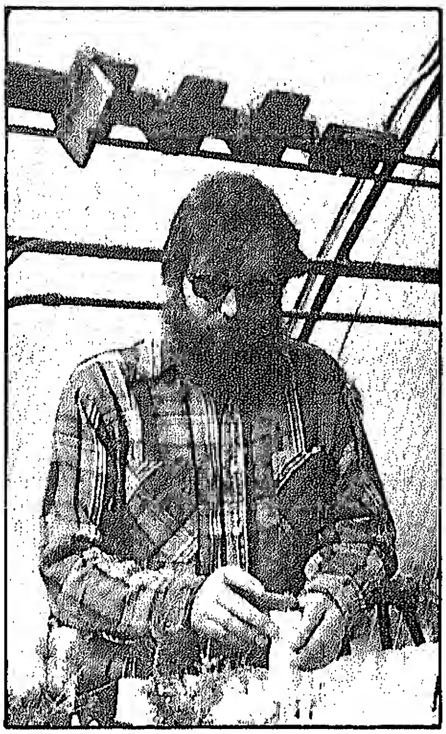
The solid sea of P-J also arouses the interest of several commercial operators who see a chance to convert these trees into fiber board, cement board, and various related building materials. Test work has been done on the fiber boards made from pinyon and juniper. The results are entirely satisfactory as far as finished products are concerned. But costs are still a bit out of line. Lower product prices from traditional timber areas have stalled inland development.

Such entrepreneurs as John McLain of Resource Concepts in Carson City, Nevada, expect that market stalemate to change. They're ready now. They have sample products, proven harvest methods, ready customers—including buyers from abroad. But the price isn't right. Not yet.

There's also a regional tradition and a surprising amount of money in the back-country business of harvesting nuts from the Great Basin pinyons. The tradition dates back to tribal history of the Paiutes, Shoshones, and Washoes—Indian tribes that depended on the pine nut harvest for winter survival. A failure of this crop, which could be roasted and stored, could spread famine through the tribes in the old days.

Ideal management of P-J woodlands for the pine nut people? Well, whatever encourages the health and expansion of mature pinyon groves. Rich Everett and his scientific colleagues will explore that.

The rising tide of environmentalist interests? Their views vary, but many think they would prefer to see the P-J woodlands left in a "natural" state. That request is not as simple as it seems. What's natural in a woodland forever manipulated by fire, flood, drought, disease, man, and wildlife? The system is dynamic and change is inevitable.



Dr. Jerry Budy works with singleleaf pinon seedlings in the Forest Service greenhouse, University of Nevada-Reno. He is testing the nutrient requirements of pinyon and methods of reestablishing pinon in cut-over areas.

Rich Everett and Susan Koniak, range scientist with the Reno unit, walk the P-J lands and return to review the scientific studies that suggest ways to manage 17 million acres to best suit the varying land and people with conflicting needs and interest. Some things seem clear. Chaining and burning to clear the land, though fast and fairly inexpensive, wastes wood that has real value. Scattering limbs and leaving them on the ground after cutting trees for wood creates a protective cover for fledgling plants and may be better than the old method of piling and burning slash. Controlled burns on the edges of established P-J stands may prove beneficial to both livestock and wildlife. Everett knows that various sites on this great expanse of P-J land have much greater potential for one use than another.

The Reno work unit is far from alone in its efforts to find the best potential uses. Cooperators include Rocky Mountain Station research units led by Frank Ronco, Jr. in Flagstaff, Arizona, and Leonard DeBano at Tempe, Arizona; and the Intermountain Station's Forest Survey unit in Ogden. Agricultural Research Service range scientists Ray Evans and Jim Young share office space and enthusiasm for pinyon-juniper research with the Reno work unit.

At western universities are such cooperators as Neil West, Utah State; Fred Gifford, Paul Tueller, Robin Tausch, Sherman Swanson, and Jerry Budy at the University of Nevada-Reno; Lee Eddleman and Steve Sharrow at Oregon State; Jack Brotherson and Kimble Harper at Brigham Young University; Rex Piper at the University of New Mexico; Richard Barth and Richard Ward at Colorado State.

"We have a common cause in our P-J studies," Rich Everett explains. "We see the needs for wood products and the other resources of P-J lands expanding rapidly. Our work will allow the land management agencies to meet those needs in the future without destruction of the resource."

The research effort is fortunate in that Forest Service, BLM, Soil Conservation Service, and State Foresters recognize the need for more information to aid in the development of guidelines for pinyon-juniper management.

On behalf of Engelmann spruce

by Rick Fletcher
Rocky Mountain Station

Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) is the most important commercial timber species in subalpine forests of the Central Rockies. In addition to providing wood products, spruce forests offer other resources that are becoming increasingly important—they grow on areas that yield the most water in the central Rockies, and provide habitat for a wide variety of wildlife, forage for livestock, developed and dispersed recreation, and scenic beauty.

However, natural regeneration of this species is a major management problem due to the harshness of the high elevation (above 9,000 ft.) environment in which it grows.

In the past, either long regeneration periods (up to 20 years or more) or regeneration failures were common in spruce forests because little attention was paid to regeneration requirements. Today, the tables are turning. Scientists at the Rocky Mountain Staion have just completed a 15-year study to help identify limiting factors and determine modifications in cultural practices needed to provide suitable environments for spruce regeneration.

Conducted at the Fraser Experimental Forest in central Colorado, the study was designed around 12 plots representing 4 seedbed treatments of 3-acre clearcut openings on both north and south aspects. The treatments simulated different post-harvesting seedbed conditions: scarified-shaded, scarified-unshaded, unscarified-shaded, and unscarified-unshaded. Scarification was done by hand (approximating scalping with a dozer blade) and removed all material to mineral soil. Researchers designed the shading (using wood frames) to represent the overstory present following thinning or harvest practices that left a residual overstory.

Spruce seeds, collected from the experimental forest, were broadcast at a rate of 1,235,000 per hectare (representing a heavy natural seedfall, and left uncovered to simulate natural regeneration).

Conditions favorable and unfavorable to natural regeneration of Engelmann spruce.

REGENERATION CONDITIONS

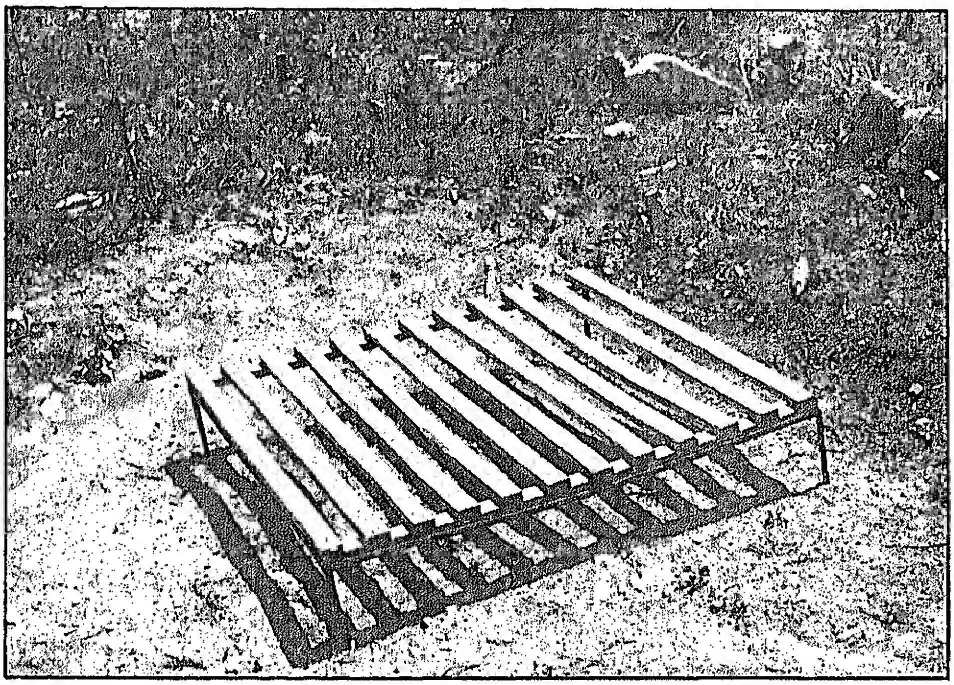
	FAVORABLE		UNFAVORABLE
a	>600,000 seed/ha	SEED CROP	<100,000 seed/ha
b	North and East	ASPECT	South and West
c	Ambient air >0°C night and <25° C day; maximum surface <30° C	TEMPERATURES	Ambient air <0° C night and >25° C day; maximum surface >30° C
d	>1.25cm week	PRECIPITATION	<1.00cm week
e	Light-textured, sandy-loam	SOIL	Heavy-textured, clay-loam
f	>40% exposed mineral soil	SEEDBED	<20% exposed mineral soil
g	50-70% dead shade		<30% dead shade
h	<5cm duff and litter		>10cm duff and litter
i	Light vegetative cover <30% non sod-forming		Heavy vegetative cover >60% sod-forming
j	Seedlings >12 weeks old by mid-Sept	SURVIVAL	Seedlings <12 weeks old by mid-Sept
k	Low population of birds and small mammals that eat tree seed and young seedlings		High population of birds and small mammals that eat tree seed and young seedlings
l	Protection from trampling		No protection from trampling
m	Fall snow cover when frost heaving conditions exist		No fall snow cover when frost heaving conditions exist
n	No late lying spring snowfields when conditions favorable to snowmold exist		Late lying spring snowfields when conditions favorable to snowmold exist

To characterize the environment on each aspect, measurements of air temperatures, precipitation, radiation, vapor pressure deficits, and wind velocity were compiled into daily, weekly, monthly, and seasonal summaries. Soil surface and subsurface, and soil profile temperatures were also summarized to characterize the microenvironment associated with seedbeds so that comparisons could be made between seedbed treatments for each aspect.

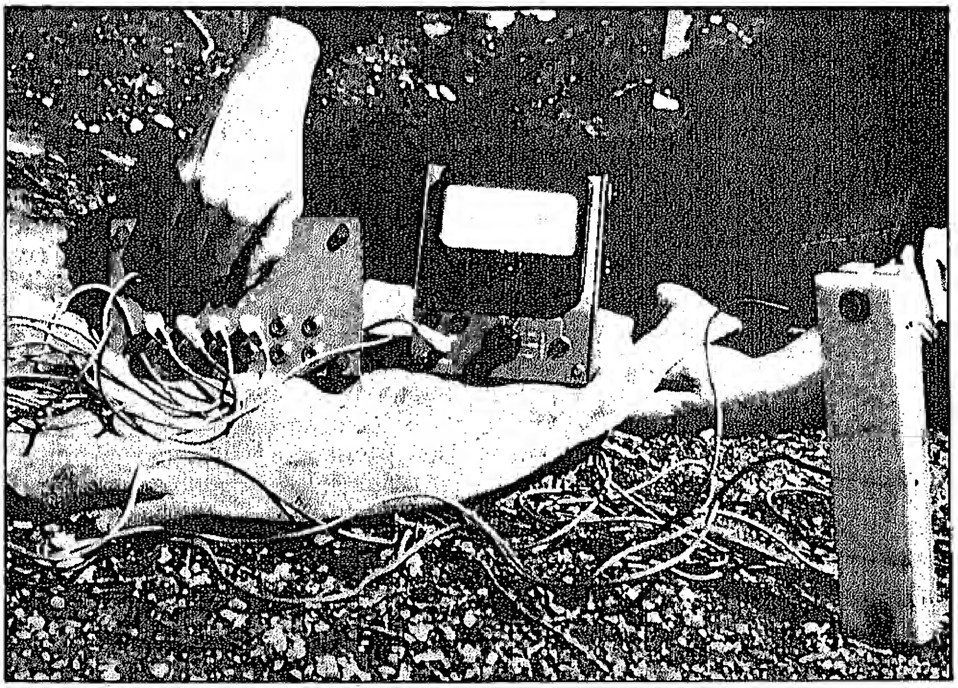
Results

Overall, scarification on both aspects, and the combination of shade and scarification on south aspects, improved germination. Germination was considerably better on the north than on the south aspect, with total germination for all years and all seedbed treatments averaging 6.1 percent. Germination on the south aspect averaged only 2.9 percent.

Seedling survival for all seedbed treatments was also better on the north (1.4) than on the south aspect (0.2 percent). Most seedlings that survived 5 years were still surviving at the end of the 15 years. Survival on the north aspect was improved by both shade and scarification, while shade was essential to any survival on the south aspect.



Shade frame in place on a north aspect, scarified-shaded treatment.



Simultaneous air-temperature profiles were measured with unshielded thermistors above the surface using a tele-thermometer and switchbox.

Seedbed treatment	Germinating seedlings			First year survival[1]			Fifth year survival[2]		
	Mean	Range	%	Mean	Range	%	Mean	Range	%
North Aspect									
Scarified shaded	11:1	5:1 to 94:1	9	18:1	9:1 to 188:1	59	32:1	10:1 to 375:1	57
Scarified unshaded	15:1	8:1 to 94:1	6	33:1	14:1 to 188:1	47	76:1	16:1 to ∞	44
Unscarified shaded	17:1	5:1 to [3]∞	6	37:1	17:1 to ∞	45	72:1	29:1 to ∞	52
Unscarified unshaded	42:1	9:1 to 375:1	2	125:1	54:1 to ∞	34	417:1	75:1 to ∞	30
South Aspect									
Scarified shaded	35:1	9:1 to ∞	3	156:1	42:1 to ∞	22	341:1	75:1 to ∞	46
Scarified unshaded	74:1	10:1 to ∞	1	1,875:1	188:1 to ∞	4	∞		0
Unscarified shaded	19:1	4:1 to 375:1	5	144:1	14:1 to ∞	13	312:1	54:1 to ∞	46
Unscarified unshaded	46:1	9:1 to ∞	2	750:1	94:1 to ∞	6	∞		0

[1]Ratio of germinating seedings to survival at the end of the first growing season.
[2]Ratio of seedlings alive at the end of the first growing season to seedlings alive at the end of 5 growing seasons.
[3]∞ = no germination or survival.

Seed to seedling ratios at the end of germination, and the first, and fifth growing seasons by seedbed treatment and aspect.

Mortality factors

Project Leader Bob Alexander, who headed the study, says, "Although drought was the most significant cause of mortality on both aspects for all treatments, losses were greater on south aspects." Here, surface temperatures averaged to 2.2° to 11.0° C higher than on north aspects. Seedbeds changed rapidly from too cold and wet for germination (following snowmelt), to too hot and dry. Higher temperatures increased moisture losses from both soil and seedlings, resulting in poorer germination and higher seedling mortality on south aspects.

Clipping of cotyledons by grey-headed juncos, and frost heaving were also significant causes of mortality. Frost heaving was especially important on the colder north aspect. It occurred most often when soil moisture was at or near field capacity, there was no vegetational or snow cover, and day/night temperatures were alternating above and below freezing. These conditions were most common during the first 2 to 3 weeks following snowmelt, and again in the fall just prior to permanent snow cover.

Snowmold was another problem on the north slope. Although it caused more damage than mortality, it occurred every year on shaded plots and in unshaded depressions where snow normally accumulated and melted slowly.

Scarification and shading a necessity

"Probably the most important result to come out of this study is a confirmation of what we expected—scarification and shade are essential to successful spruce regeneration," said Alexander.

The lowest seed/seedling ratios were on the scarified-shaded seedbeds on the north aspect. Here, where the layer of organic material was 7 cm or more thick, scarification improved germination and survival by increasing available soil moisture. Shade reduced soil and air temperatures, evapotranspiration losses, and frost heaving by preventing excessive moisture losses and reducing radiation cooling at night.

In contrast, the organic layer on the south aspect was less than 5 cm thick and scarification was less effective. "However," says Alexander, "because of high soil surface temperatures, it is likely that scarification would be less effective on south aspects, regardless of the thickness of the organic layer."

Neither shade nor scarification alone was as effective as the combination of the two on north aspects. It required 2.5 times as many seeds to produce a 5-year-old seedling on the scarified-unshaded and unscarified-shaded seedbeds as on the scarified-shaded seedbeds. On the unscarified-unshaded seedbeds, nearly 13 times as many seeds were required to produce a 5-year-old seedling as on the scarified-shaded seedbeds. Compared to equivalent seedbeds on the north aspect, it required more than 10 times as many seeds on scarified-shaded seedbeds and

nearly 5 times as many on the unscarified-shaded seedbeds to produce a 5-year-old seedling on the south aspect. "The fact that shade was essential to any regeneration success on the south aspect, and shade and scarification improved survival on the north aspect, reflects the importance of reducing water losses from soil and seedlings in clearcut openings," said Alexander.

Stocking goals

Scientists suggest that a reasonable stocking goal for Engelmann spruce is 1976 seedlings per hectare at age 5 years. While this is more than required for adequate stocking, it is necessary to achieve uniform spacing, allow for possible future mortality, and provide options in selecting crop trees in subsequent thinnings.

Based on this stocking goal, scarified-shaded seedbeds on north aspects in small clearcut openings should restock within a 5-year period, but may require more than one good seed year. It will require a number of good seed years to restock scarified-unshaded and unscarified-shaded seedbeds, and is not likely to occur within a 5-year period. Unscarified-unshaded seedbeds on north aspects are not likely to restock adequately within a 20-year period.

On south aspects, small clearcut openings are not likely to restock adequately, regardless of cultural treatments. They should be regenerated with cutting methods that either take advantage of advanced reproduction or provide understory protection for new natural or planted reproduction.

Although there are many barriers to natural regeneration of Engelmann spruce, these research results indicate that success on north slopes after clearcutting small openings can be achieved through carefully planned and well-designed cultural treatments that emphasize scarification and shading.

For more information on this study, write the Rocky Mountain Station and ask for *Natural Regeneration of Engelmann Spruce after Clearcutting in the Central Rocky Mountains in Relation to Environmental Factors*, Research Paper RM-254.

Percent total mortality by aspect, cause and seedbed treatment (basis number of seedlings that germinated).

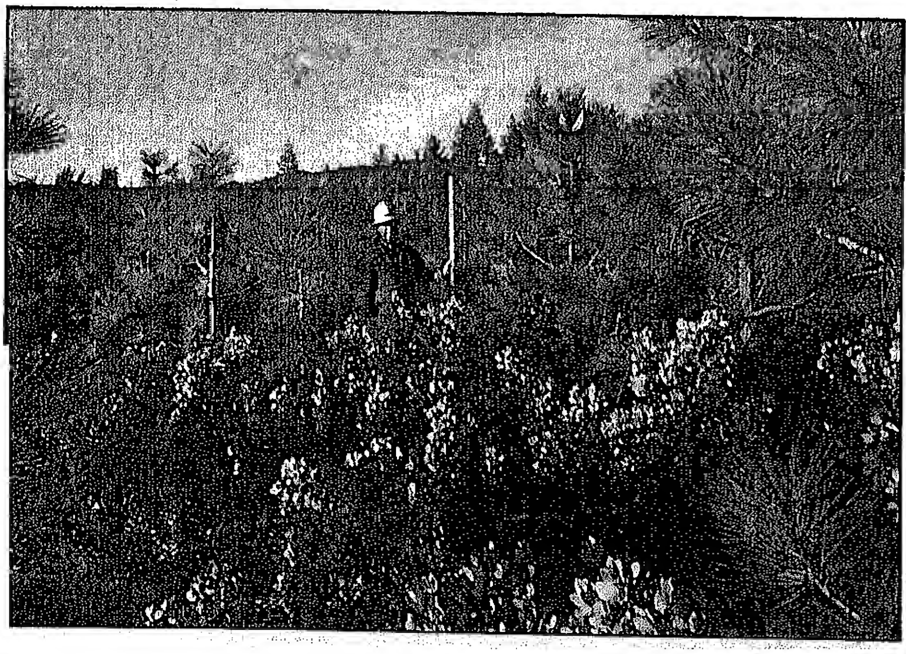
Cause of Mortality	Scarified-Shaded			Scarified-Unshaded			Unscarified-Shaded			Unscarified-Unshaded			Total		
	End 1st yr	End 5th yr	End study[1]	End 1st yr	End 5th yr	End study	End 1st yr	End 5th yr	End study	End 1st yr	End 5th yr	End study	End 1st yr	End 5th yr	End study
North Aspect															
Drought	9.9	14.2	14.2	8.3	9.9	9.9	15.6	20.2	20.5	7.8	10.4	10.4	41.6	54.7	55.0
Clipping	7.2	7.2	7.2	6.1	6.1	6.1	1.3	1.3	1.3	0	0	0	14.6	14.6	14.6
Frost heave	0.3	6.4	6.4	0.6	4.5	4.5	0.1	0.7	0.7	0	0.5	0.5	1.0	12.1	12.1
Snow mold	0	0.9	1.3	0	2.6	2.6	0	0.7	1.2	0	0	0	0	4.2	5.1
Washout	2.0	2.3	2.3	1.0	1.2	1.2	0	0	0	0	0	0	2.9	3.5	3.5
Freezing	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.7	0.7	0.7	0.7	0.7	1.1	1.6	1.6
Heat girdle	0.7	0.7	0.7	0.9	0.9	0.9	0.1	0.1	0.1	0	0	0	1.7	1.7	1.7
Other[2]	0.9	1.9	2.0	1.4	2.5	2.5	0.6	1.8	1.9	0	0	0	2.9	6.2	6.4
Total	21.0	33.7	34.2	18.3	27.8	27.8	18.1	25.5	26.4	8.5	11.6	11.6	65.8	98.6	100.0
South Aspect															
Drought	10.1	11.1	11.1	7.7	7.7	7.7	23.8	26.0	26.5	13.9	14.7	14.7	55.5	59.5	60.0
Clipping	7.0	7.0	7.0	0.5	0.5	0.5	10.8	10.8	10.8	1.2	1.2	1.2	19.5	19.5	19.5
Frost heave	0.5	2.2	2.4	0.5	0.9	0.9	0.5	0.5	0.5	0	0	0	1.5	3.6	3.8
Snow mold	0	0	0	0	0	0	0	0.2	0.2	0	0	0	0	0.2	0.2
Washout	1.2	1.2	1.2	0.7	0.7	0.7	0	0	0	0	0	0	1.9	1.9	1.9
Freezing	0	0.2	0.2	0	0	0	0.5	0.5	0.5	0	0	0	0.5	0.7	0.7
Heat girdle	1.0	1.0	1.0	1.7	1.7	1.7	4.8	4.8	4.8	2.6	2.6	2.6	10.1	10.1	10.1
Other[3]	0.2	0.5	0.5	0.7	0.7	0.7	1.0	1.9	1.9	0.7	0.7	0.7	2.6	3.8	3.8
Total	20.0	23.2	[4]23.5	11.8	12.2	12.2	41.4	44.7	45.2	18.4	19.2	19.2	91.6	99.3	100.0

[1]*Seedlings age at end of study (1982) varied from 5 to 14 years old.*
[2]*Includes isolation, damping off, gophers and unknown.*
[3]*Includes isolation, damping off and unknown.*
[4]*Seedlings age at end of study (1982) varied from 10 to 14 years old.*

From seedling to sawlog

by Kevin Shea

In a 16-year-old ponderosa pine plantation thinned to different spacings on a poor site, growth is being studied of trees (A) released, and (B) unreleased from brush.



The climate over most of California's timber producing forest lands, together with a group of superbly adapted brush species, provide a combination of conditions that present forest scientists at the Redding, California facility of the Pacific Southwest Station with some of the most vexing regeneration and growth problems to be found in North America.

At the top of the list is how to deal with brush species that quickly invade forest openings because of fires or timber harvest, and all but preclude the re-establishment of a healthy, fast growing stand of commercial timber species.

This is especially troublesome in the mixed conifer forests of the Sierra Nevada, where hot, dry summers favor species with built-in regeneration and growth strategies that allow them to invade and thrive in harsh environments.

The so-called broad sclerophyll brush species fit these conditions perfectly. They thrive on a large variety of sites; they are aggressive invaders, prolific reproducers, and tenacious competitors. As a group they are the bane of forest managers, and forest scientists are only beginning to understand how important these plants can be in determining future timber yields from western forests.

Among the broad leaf sclerophyll species that are giving foresters problems are a number of species of manzanita and ceanothus, a few oak-like species including tanoak and chinkapin, as well as Pacific madrone and wild plum. In the commercial timber growing areas of southern Oregon and California, there are about 50 species of broad sclerophylls — not all of which are troublesome to forest managers. However, those that do interfere with the establishment and growth of young conifer forests comprise one of the most important biological factors in determining future timber yields from California forests.

Phil McDonald, a research scientist, speaks about the broad sclerophylls with a kind of grudging admiration. McDonald is involved in a number of projects that center on the regeneration and growth of young commercial timber species. One of his major tasks is to develop strategies and techniques to reduce competition from brush species on young commercial plantations. As an ecologist, he is impressed by the survival and growth tactics of the broad sclerophylls.

McDonald believes in the old admonition, "know your enemy." In a 1981 paper he reviewed what he calls a small portion of the available scientific literature on the broadleaf sclerophylls and came up with no less than 20 adaptations of form and function that help to explain why this group of plants is so successful under such a variety of conditions. By compiling a detailed dosier on these plants, McDonald hopes to discover a weakness in their biology that could be exploited to the advantage of forest managers. While no such flaw has been found — and McDonald readily admits that none may exist — his studies have given him a better understanding of the "enemy."

McDonald explains to forest managers in California and parts of southern Oregon that when they are faced with regeneration problems due to competition from brush they are up against 20 million years of evolution that has "fine-tuned" the survival mechanisms of the broad sclerophylls. "You cannot expect successful regeneration" says McDonald, "unless you adequately control these species." That, however is no easy task.

Alternatives to herbicides

The current moratorium on the aerial application of herbicides — according to McDonald the most effective and cheapest brush control technique — has seriously hampered efforts to maintain fast early growth in plantations and to convert brushfields to stands of commercial conifer species.

The controversy over the phenoxy herbicides has also prompted a major effort to find alternative ways to control brush. In 1980, the Pacific Southwest Station and Pacific Southwest Region (USFS) began a cooperative effort to evaluate the effect of a variety of techniques and combinations of techniques for releasing conifer seedlings from competition with brush. Among the techniques being evaluated are mechanical, chemical and manual treatments as well as the use of grazing animals. Gary Fiddler, a forester from the Pacific Southwest Region is working with McDonald in this study, and the two have established 12 study areas on 6 National Forests where they will evaluate 9 treatments and combinations of treatments. Results of this project will be grouped into four broad categories of data: cost and production data; moisture stress relationships; conifer growth response; and shrub dynamics. Fiddler and McDonald have made some preliminary observations, but are 2 to 3 years from publishing major findings. However, because of the urgent need for the kind of information they are compiling, the two scientists have decided to publish preliminary findings at each location as soon as trends can be recognized.

Growth and Yield

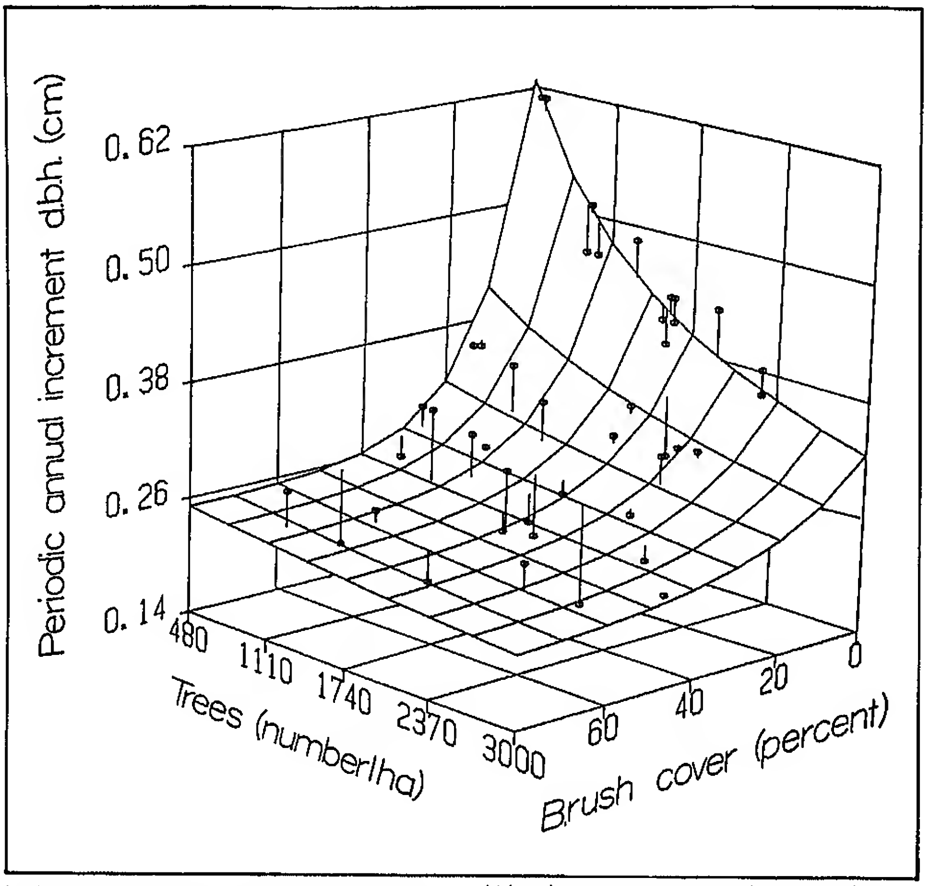
McDonald and colleague Bill Oliver, another research forester at Redding, are also making a dent in conventional wisdom about the influence of brush on the growth and yield of young ponderosa pine plantations.

Between 1960 and 1970, they began a group of studies at four widely separated sites that ranged in quality from poor to very good. The purpose of these studies was to refine knowledge about the effect of brush growth on conifer seedlings and saplings. Two of the studies focus on brush ecology while the two others involve measuring growth and yield as it is affected by tree spacing and competition from brush. When added to an already existing body of information, the data being compiled from these four studies have given McDonald and Oliver some definite ideas about brush control — some of which are not universally accepted. For example, many forest managers believe that after slowing down brush growth enough to allow seedlings to become established, it is no longer necessary to allocate resources for further brush control. In contrast, McDonald and Oliver have concluded that *any* amount of brush will have an effect on the growth and yield of conifer plantations. Their study results tend to confirm this conclusion for a variety of site conditions and at all tree spacings tested.

But even as McDonald and Oliver are zeroing in on some pretty basic questions about how competition from brush can affect growth and yield of commercial species, there remains some even bigger questions about how to put this information to use. Bill Oliver just smiles when asked about how his work will translate into action on the part of forest managers. "Cost-benefit analyses are almost witchcraft" replied Oliver. "All we can do is play 'what if games.' We can tell people what will happen if they take certain actions. But that is only part of the problem. Timber prices at the end of the cutting cycle, changes in labor and materials cost during the cutting cycle and any number of other factors have an impact on how much should be invested in any particular stand." McDonald and Oliver agree on their objective — to gather enough information to allow them to describe for forest managers what they can do to grow the biggest tree in the shortest amount of time.

Fertilizers in forests

In another project at Redding, Research Scientist Bob Powers is investigating the potential benefits of applying nitrogen fertilizer to forest stands in order to increase growth. While he is enthusiastic about the prospects, Powers is also cautious about the future of fertilizers in the management of California forests. In a . "The



At brush coverages greater than about 30 percent, periodic annual diameter increment of ponderosa pine planted at a poor site, was similar regardless of tree spacing.

In 1975, the Station, together with the Pacific Southwest Region, embarked on a 10-year, cooperative research effort to systematically gather information on tree response to fertilizers. By 1980 Powers and his colleagues had established 50 installations in all major forest types except redwood. Each installation ...sts of a control and two test ...e of which receives 200 ...of nitrogen and the other 400 ...of nitrogen applied as urea ... first fall rains. Replications ...ng and weeding were also ... At each installation, Powers ... recording information on ...nistry, soil chemistry, ...soil/water chemistry and ... of foliage.

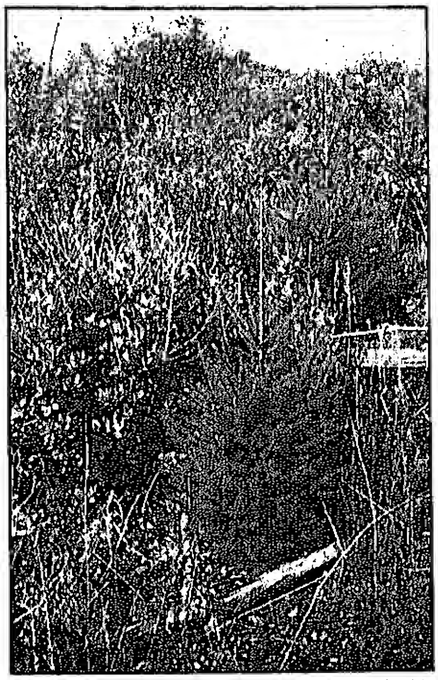
As one would expect, early observations from this study are highly variable and are based on soil type, stand condition, size class, and climate, to name just a few variables. Tree growth response to treatments ranges from 134 percent to -22 percent. By continuing to add to this storehouse of information Powers hopes to eventually have enough information on fertilizer treatments to materially aid forest managers.

It should also be pointed out that Powers is well aware of the problems with water quality that can result from the use of fertilizers. Part of this research effort is being devoted to isolating the conditions that lead to high levels of nitrates in drinking water and devising tactics to avoid the problems that have resulted from the agricultural use of nitrogen fertilizers.

High tech forestry

Jim Laacke, another research scientist at Redding, is tinkering with some highly technical equipment that he hopes will help him solve another major silvicultural problem. That is, how can seedling nurseries produce seedlings with a consistently high survival rate at the lowest cost possible?

To provide some answers, Laacke is focusing on two areas: devising a method of sorting seeds according to how quickly they will germinate and how fast they will grow; and developing a less expensive method of determining when to lift seedlings out of the ground in the fall for cold storage and planting in spring.



Three years after the tanoak was sprayed with 2,4-D, this 6-year-old Douglas-fir seedling on the Six Rivers National Forest, California, is beginning to "take off."

Laacke has a hunch, and that is exactly how he describes it, that it may be possible to detect a difference between seeds that appear identical in every respect. Like a physics teacher, Laacke points out that every bit of matter emits radiation in the infra-red range that is peculiar to its temperature, and seeds are no exception. Thus, with a sensitive instrument, one can actually record the temperature of a seed. Laacke's hunch however, is that a tiny difference in the temperature of two seeds, for example, may mean that they have characteristically different metabolic rates. A high metabolism, Laacke speculates, may mean a fast germination time or perhaps a fast rate of early growth.

If this all works out, nurserymen will have an invaluable tool for grading seed and producing highly uniform growth in seed beds.

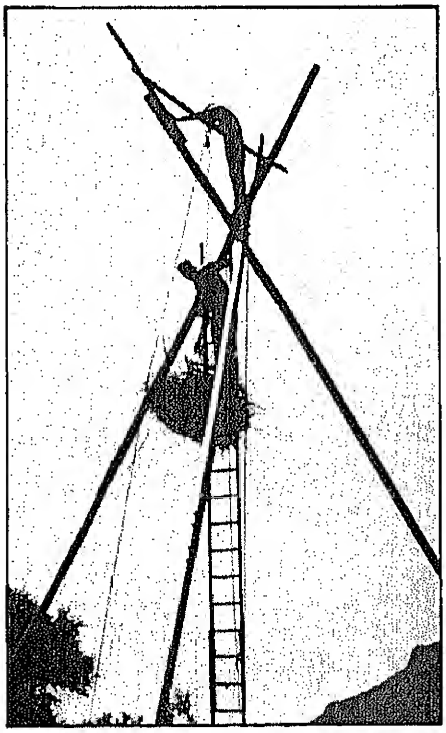
A second problem that might be solved measuring infra-red radiation is determining the best time to take seedlings out of their planting bed. The so-called "lifting-window" can be determined quite accurately by a standardized test, but it is both laborious and expensive. The opening of the lifting window occurs when the seedling enters a state of internally controlled dormancy. At this point Laacke thinks he will be able to "sense" minute changes in temperature of the plants. Indeed, by using a device called an imaging radiometer, Laacke can detect differences in temperature between seedlings that he has scanned with the radiometer. But Laacke is well aware that many variables affect the internal temperature of a plant, and that he must now get on with the chore of sorting all this out. Should he be successful, nurseries could be operated with a great deal more precision, with less cost and a much greater survival rate for each seedling produced.

New publications

Artificial nests for Bald Eagles

Rocky Mountain Station scientists in Arizona have observed a remarkable measure of adaptability in nesting Bald Eagles. Following two nesting failures of a breeding pair of eagles (due to loss of the nest, and finally loss of the nest tree), an aluminum tripod was erected and materials from the original nest were used to construct a new nest atop the structure.

At first the birds used it only for perching and roosting. However, they later took up residence there and successfully deposited eggs. Acceptance of the reconstructed nest atop the tripod suggests that artificial nests and nesting structures are viable alternatives to natural ones, and may prove helpful in improving bald eagle habitat.



For details on this study and its implications for managers, write the Rocky Mountain Station and request the reprint *Bald Eagle Activity at an Artificial Nest Structure in Arizona.*

Brush reduces growth of ponderosa pine

Forest managers have long recognized that stocking control can affect the growth and vigor of potential crop trees in young plantations of ponderosa pine. Most recommendations on stocking level, however, are for stands that have little or no understory brush. And yet brush is the common and aggressive competitor that robs ponderosa pine of soil moisture and nutrients. Until recently, the effectiveness of plantation management has been hampered by paucity of information about the interrelationships of levels of tree stocking and competing brush quantities.

Silviculturists at the Pacific Southwest Station tested the effects of tree spacing and brush competition on a ponderosa pine site of low productivity in California's North Coast Range. They thinned 11-year-old saplings to four square spacings ranging from 7 to 14 ft, and manually removed all, half, and none of the understory brush in the split-plot design.

The results suggest that for the plantation studied, any amount of brush will restrict diameter growth. Spacing significantly affected diameter growth only when all brush was removed, but did not affect height growth and stem volume production. The researchers concluded that even small amounts of brush can restrict tree growth markedly, and that the major tree growth losses found in their study should prevail in similar plantations on sites of low productivity.

The report of the study, by William W. Oliver, is available from the Pacific Southwest Station, in Research Paper PSW-172, *Brush Reduces Growth of Thinned Ponderosa Pine in Northern California.*

Decay losses low after spruce budworm attack

Trees damaged during an outbreak of the western spruce budworm in the Wenatchee and Okanogan National Forests in eastern Washington between 1970 and 1979 suffered little loss from associated decay, researchers have found.

Plant Pathologist Paul Aho at the Pacific Northwest Station looked at 133 Douglas-fir trees and 69 true firs with dead tops. Trees were felled, dissected, and examined for height loss and incidence and extent of decay. Height losses of trees severely damaged by top-kill averaged 4.3 feet for Douglas-fir and 4.4 feet for true firs, but some trees developed new tops with an average length of about a foot. Only three trees were infected by decay fungi and associated loss of volume in those trees was negligible.

Aho concludes that under conditions similar to the 14 stands sampled, decay losses associated with dead tops should be very low. If deductions for decay are made, they should be made for dead tops with large basal diameters and for secondary attacks by beetles. Even under those conditions, however, decay losses would be low because the tops have not been dead long enough for extensive columns of rot to develop.

Details are in Research Paper PNW-318, *Losses Associated with Douglas-fir and True Fir Tops Killed by the Western Spruce Budworm in Eastern Oregon*, by Paul E. Aho.

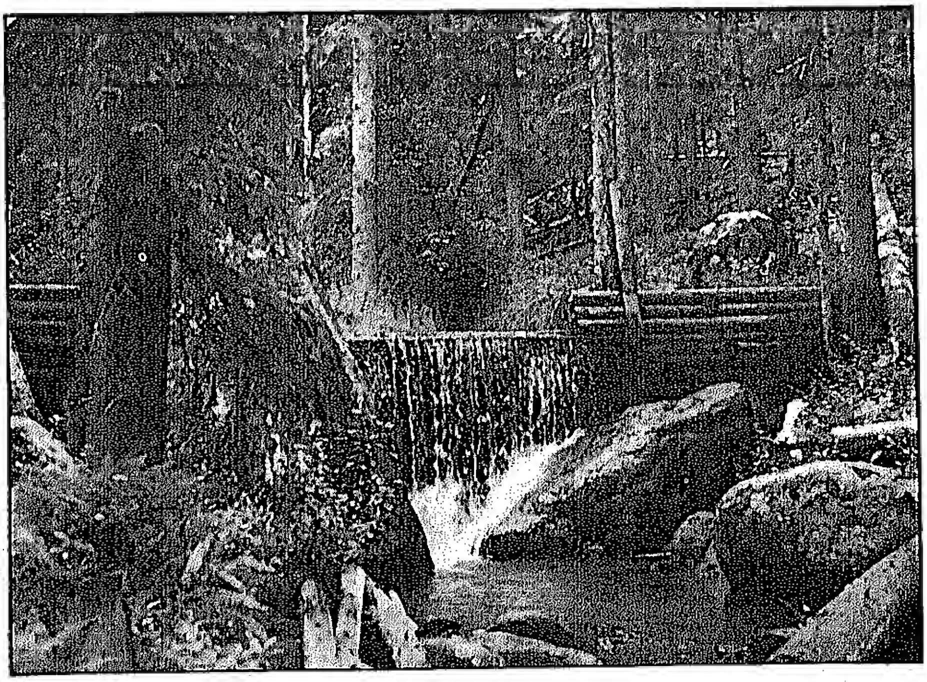
Arizona stream index published

Perennial water in Arizona is an increasingly vital resource for domestic, agricultural, and industrial uses, and is essential for wildlife and fish habitat. Yet, exclusive of a handful of stream maps, only U.S. Geological Survey publications on major surface waters attempt amassing data on more than a few of the perennial streams.

To help meet this need, a comprehensive catalog of all perennial waters in that state has been compiled. Developed primarily for fisheries and wildlife biologists, it should prove a valuable tool in helping to meet the requirements of the Resources Planning and National Forest Management Acts, and other Federal and State legislation.

The 554 waters listed vary in magnitude from the Colorado River to minute streams rarely exceeding a few hundred meters of perennial flow. A digital identification, name and geographic location are presented for each. When available, fishery resources are identified and reference provided for respective streams. A similar index for New Mexico is being compiled.

Copies of *RUN WILD: Wildlife/Habitat Relationships - Index to the Natural Drainage Systems of Arizona—A Computer Compatible Digital Identification of Perennial Lotic Waters* are available from the Rocky Mountain Station.



Computing costs of fire suppression

The emphasis on economic efficiency in the nation's fire management programs has led to efforts to develop more accurate cost estimates of those programs. Such estimates are essential in the economic analyses needed in long-term planning.

Current cost estimates available for such planning purposes do not provide accurate economic cost estimates. Nor are they in a form usable in simulation models being developed to analyze the economic efficiency of fire-management programs.

To fill this gap, the Pacific Southwest Station has developed a cost-aggregation approach for estimating the cost of two major fire management activities: initial attack and large-fire suppression. The approach was used to determine the hourly costs of direct fireline production units—termed Fire Management Inputs (FMI)—used in these two activities. All components contributing an FMI are identified, computed, and summed to estimate economic costs. These include crew, equipment, supplies, and overhead.

The approach was developed and tested by collecting and analyzing cost data from three Forest Service Regions (Northern, Southwestern, Pacific Northwest) and three State forestry agencies (California, Montana, Oregon).

This cost-aggregation technique is generalized enough to be useful to any organization with fire protection responsibilities. Details are available in Research Paper PSW-171, *Costs of Fire Suppression Forces Based on Cost-Aggregation Approach*, from the Pacific Southwest Station.

Gambel oak fuelwood management

Gambel oak covers millions of acres in Arizona, Colorado, New Mexico, and Utah, and often in accessible stands, and has a high heat value that is making it the darling of many firewood seekers. But is it practical and economical to manage Gambel oak for fuelwood?

Yes, concludes a study by research economist Fred Wagstaff of the Intermountain Station, although results from his sample sites in north-central Utah must be applied with caution because of variance in local conditions.

The Utah study showed minimum fuelwood sizes could be reached with rotation ages of 65 years. Current retail stumpage prices for fuelwood ranged from $115 to $2,300 per stocked acre. Wagstaff says the value of Gambel oak areas as wood-producing sites could well exceed the value of other uses of the land.

Complete results of the study are available in Intermountain Station General Technical Report INT-165, *Economic Considerations in Use and Management of Gambel Oak for Fuelwood.*

Economic potential of dead lodgepole pine

Researchers estimate that if all the material from the six harvest units had been chipped, 4,329 tons of ovendry chips would have been produced. That's the fuel equivalent of 17.4 million BTU's. Only .59 million BTU's were required to harvest and deliver that ton of material—a mere 3.4 percent of the energy available in the chips. Even more significant is the fact that dead lodgepole pine can be burned at an average efficiency of 75 percent, compared to an average efficiency of 65 percent or less for most wood fuels.

Do stands of dead lodgepole pine in the West have economic value for fuel or other products? Researchers at the Pacific Northwest Station conducted a 3-month study in northeastern Oregon in 1979 to try to find out.

There is no single answer because timber harvest and transportation costs vary from one market area to another. But what researchers found in the Blue Mountains of eastern Oregon is interesting. In all, 197 van loads of chips and 6,249 trimmed house logs and sawlogs were recovered from six harvest units. Total "wet" weight of chips (weight is also given ovendry) was 4,171 tons, or an average of approximately 31 tons per acre. Total "wet" weight of logs was 1,385 tons or an average of about 10 tons per acre.) Delivered costs (harvest cost plus transportation cost) averaged $50.28 per "wet" ton for logs and $31.30 per "wet" ton for chips.

See *Costs of Harvesting Beetle-killed Lodgepole Pine in Eastern Oregon*, General Technical Report PNW-165, by Peter J. Ince., John W. Henley, John B. Grantham, and Douglas L. Hunt.

Bulldozer fireline rates updated

Much has changed in firefighting technology in recent years, and that dependable fireline builder the bulldozer is no exception.

Fire management consultant Clinton B. Phillips and Intermountain Station researcher Richard J. Barney recently completed a report that gives fire managers line production data for bulldozers manufactured from 1965 to 1975, the bulk of the units in use today. Results are in Intermountain Station General Technical Report INT-166, *Updating Bulldozer Fireline Production Rates.*

The report shows fireline production rates in chains per hour for several slope classes. Production indexes devised by manufacturers for 38 pieces of equipment were analyzed. Machines are grouped into small, medium, and large classes. The work resulted in current graphs that can be used easily by managers to calculate production.

Revegetating western mine spoils

Most surface mining in the U.S. is in semiarid to arid regions. Even though commodities differ, problems encountered in reclaiming mined lands are usually similar.

The Rocky Mountain Station has published a report that details efforts to establish trees and shrubs on lands disturbed by mining in the West, with emphasis on the northern Great Plains. The author covers past successes and failures, and factors to consider for further reclamation efforts. Both dry land and irrigation techniques are covered, and suggestions are offered on plant species to use.

For your copy, write the Rocky Mountain Station and request the reprint *Establishment of Trees and Shrubs on Lands Disturbed by Mining in the West.*

Shaking trees to collect the cones

Douglas-fir trees in a seed orchard in Oregon got "all shook up" a few years ago. They were the object of an experiment to find out if mechanical shaking could speed up cone harvest.

The study was undertaken because of problems associated with harvest of cones from Douglas-fir seed orchards: Cones must be harvested prior to natural seedfall and as trees become larger, hand picking becomes more difficult. Although mechanical equipment is used to harvest many other kinds of fruits and nuts, cones are still picked by hand in Douglas-fir seed orchards. It's not because foresters are behind the times. More likely, it's because tests have previously shown that many conifers do not readily drop their cones when shaken.

Results at the Douglas-fir seed orchard were more promising: more than half the cones were removed and the remaining cones were hand picked more easily after shaking. A combination of machine harvesting and hand picking can speed up cone harvest and reduce collection costs. Some damage will occur to upper crowns at any shake frequency powerful enough to remove cones, but damage can be minimized if low-energy shaking techniques are used.

The experiment was conducted by the Pacific Northwest Station at the Forest Service Beaver Creek Seed Orchard near Corvallis, Oregon. A commercially developed nut and fruit tree shaker was used to remove cones from 7- to 9-meter tall grafted Douglas-fir trees. Ninety-two trees were shaken. Different combinations of shake cycle per second and different weights were used to create different shake force.

See *Tree Shaking Machine Aids Cone Collection in a Douglas-fir Seed Orchard*, Research Note PNW-406, by Donald L. Copes and William K. Randall.

Classifying vegetation in Hawaii

The Pacific Southwest Station has just published a system of vegetation classification in Hawaii that will make it easier for resource managers to understand each other.

In developing the system, Michael G. Buck of the Hawaii Division of Forestry and Timothy E. Payson of the Pacific Southwest Station recognized the wide variety of classification systems. In Hawaii, the growing interdisciplinary responsibilities in resource management have resulted in a diversity of languages used to describe vegetation. Managers need a classification system that names vegetative communities in terminology acceptable to various disciplines it represents that can be used as a basic language among them. And it is this language that would enable managers to "talk to each other."

The report *A System of Vegetation Classification Applied to Hawaii* provides that language. The hierarchy of the system consists of five levels: formation, subformation, series, association, and phase. The classification becomes progressively more precise as it moves through the five levels.

This new system can be put into a variety of uses, such as multi-resource forest inventory, but its main function is to serve as a basic language in resource management. It provides a framework to identify missing gaps in our knowledge of vegetation communities, and serves as a logical format to display and communicate this knowledge. Although the system was developed for Hawaii, it can be applied to other Pacific islands.

For a copy of the report, write to the Pacific Southwest Station, and ask for General Technical Report PSW-76.

Don't wait for middle age

If you're planning to carry over-stocked western larch stands to middle age when they become candidates for crop-tree thinning, you may want to reconsider.

Results of a study reported by Intermountain Station researcher Dennis M. Cole show disappointing diameter gains 25 years after 50-year-old larch was thinned by two crop-tree rules. Cole recommends low thinning at younger ages for stands similar to those studied in the Petty Creek drainage, Lolo National Forest.

Complete study results are available from the Intermountain Station. Order Research Paper INT-328, *Crop-tree thinning a 50-year-old western larch stand: 25-year results.*

'o order any of the publications listed in this issue of *Forestry Research West*, use the order cards ielow. All cards require postage. Please remember to use your Zip Code on the return address.

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☐ *Bald Eagle Activity at an Artificial Nest Structure in Arizona*, a reprint.
☐ *RUN WILD: Wildlife/Habitat Relationships - Index to the Natural Drainage Systems of Arizona—A Computer Compatible Digital Identification of Perennial Lotic Waters.*
☐ *Natural Regeneration of Engelmann Spruce after Clearcutting in the Central Rocky Mountains in Relation to Environmental Factors*, Research Paper RM-254.
☐ Other ______________________

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Please send the following Pacific Southwest Station publications:

☐ *Brush Reduces Growth of Thinned Ponderosa Pine in Northern California*, Research Paper PSW-172.
☐ *A System of Vegetation Classification Applied to Hawaii*, General Technical Report PSW-76.
☐ *Costs of Fire Suppression Forces Based on Cost-Aggregation Approach*, Research Paper PSW-171.
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☐ *Tree Shaking Machine Aids Cone Collection in a Douglas-fir Seed Orchard*, Research Note PNW-406.
☐ *Costs of Harvesting Beetle-killed Lodgepole Pine in Eastern Oregon*, General Technical Report PNW-165.
☐ *Losses Associated with Douglas-fir and True Fir Tops Killed by the Western Spruce Budworm in Eastern Oregon*, Research Paper PNW-318.
☐ *Baculovirus: An Attractive Biological Alternative*, a reprint, distribution No. 83-188.
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Please send the following Intermountain Station publications:

☐ *User's Guide to the Stand Prognosis Model*, General Technical report INT-133.
☐ *User's Guide to the Regeneration Establishment Model—A Prognosis Model Extension*, General Technical Report INT-161.
☐ *Updating Bulldozer Fireline Production Rates*, General Technical Report INT-166.
☐ *Economic Considerations in Use and Management of Gambel Oak for Fuelwood*, General Technical Report INT-165.
☐ *Crop-tree Thinning a 50-year-old Western Larch Stand: 25-year Results*, Research Paper INT-328.
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Prognosis progress: version 5.0 is out

This summer marks the release of Version 5.0 of the Stand Prognosis Model. The new version was developed by scientists at the Intermountain Station's Moscow Forestry Sciences Laboratory and is primarily applicable to the forests of the Inland Northwest. Efforts are under way to calibrate the model for other geographic regions.

Version 5.0 features biological models that better represent the effects of stand density on the development of trees and stands. As a result, the model is more responsive than previous versions to management activities.

Other changes will facilitate user interaction with the program and give a more complete description of stand development:

- —A Regeneration Establishment Model predicts the establishment of seedlings following site disturbances;
- —An Event Monitor schedules management activities contingent on predicted stand and tree attributes;
- —A soon-to-be-released revision of the Shrub and Canopy Model will enhance the description of the stand canopy and provide estimates of shrub composition and growth rates.

For information on how you can receive a machine-readable copy of the program and supporting documents, please contact William R. Wykoff at:

Intermountain Forest and Range Experiment Station
1221 South Main Street
Moscow, ID 83843
Com. Tel. (208) 882-3557

If you want to learn more about the Prognosis Model, order General Technical Reports: INT-133, *User's Guide to the Stand Prognosis Model* by William R. Wykoff, N. L. Crookston, and A. R. Stage; and INT-161, *User's Guide to the Regeneration Establishment Model—A Prognosis Model Extension* by D. E. Ferguson and N. L. Crookston, using the card included in this issue.

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